ANOMALOUS INTENSITIES DUE TO THE KORAKONUI EARTHQUAKE, 5 DECEMBER, 1976

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ABSTRACT

The intensities produced by the Korakonui earthquake were unusually great for a shock of magnitude 5.0. This appears to be a consequence of an exceptionally shallow focus, but cannot be explained by geometrical factors alone. A lesser effect is related to foundation charactertistics. If the unexpectedly high intensities observed are typical of shocks in this part of New Zealand, re-assessment of existing anti-seismic precautions is advisable.

The Korakonui earthquake of 5 December, 1976 occurred at 5-57 p.m. N.Z. Daylight Time ($04^h\ 57^m$ U.T.) and was felt in most places lying west of the Waikato River, causing some public alarm. Scattered minor damage extended from Hamilton to Te Kuiti, with isolated instances at greater distances from the epicentre. This lies in a rural area (Figure 1) the nearest townships being Te Awamutu, Otorohanga, Tokoroa and Putaruru, all about 25 km away.

The New Zealand Seismological Report assigns the shock a magnitude of 5.0 and an epicentre at $38^o.10$ S, $175^o.54$ E (Origin 76/1061), but the preferred solution discussed below places it about six kilometres farther south west, near the settlement of Korakonui, where the greatest damage occurred. Here several houses within a radius of a few kilometres lost chimneys and suffered other damage indicating an intensity of MM-VIII. Unlike similarly damaged property at Cambridge, these houses stand on firm ground, and the maximum intensity can be considered adequately established. In all some 60 insurance claims were received by the Earthquake and War Damage Commission.

Figure 2 shows generalised isoseismals based upon the reports of the insurance assessors and upon 98 replies to standard questionnaires issued by the Seismological Observatory. The pattern is only slightly elliptical, with the major axis running roughly north and south, but prevailing intensities are rather greater in places to the north and west of the epicentre than in places to the east.

The statistical analysis presented by W. D. Smith (1976) suggests that an earthquake of magnitude 6.0 is needed to produce an epicentral intensity of MM-VIII, assuming that the shock belongs to his type B, which is not only the type thought appropriate to this part of the country, but is the one yielding the highest intensities. For a magnitude 5.0 shock the intensity on firm ground should not exceed MM-VI. Smith's analysis further suggests that in this case the mean radii of the MM-V and MM-IV isoseismals should be 22 and 55 km respectively, while the observed values are of the order of 50 and 75 km. There is no reason to suspect an error in the magnitude assigned to the shock.

Abnormally high intensities are commonly ascribed either to poor foundation conditions, or to an unusually shallow origin. The scatter of intensities within the larger settlements, which commonly reaches three degrees of the modified Mercalli scale, seems to be related to differences in foundation; but poor foundations alone will not explain the overall high values. In Figure 1 shading has been used to indicate the areas of Recent alluvium or other imperfectly compacted material. The mean distances at which a given intensity was observed were separately calculated both for the entire macroseismic area and for a number of subdivisions of the data. If intensity is plotted against mean distance, the smoothed curved for the values on alluvium lies slightly above that for places on firm ground, but the scatter is large and the difference only marginally significant. High values were reported both within the swampy depression extending southwards from Hamilton and on the solid volcanic foundations to the west of it.

The most obvious manner in which a reduction in the focal depth of an earthquake of given magnitude could affect the intensities experienced at the surface is a geometrical one. Smith does not explicitly assign a focal depth to his type B shocks, but the examples he discusses and their geographical distribution suggests that they are those conventionally assigned a depth of 12 km in the N.Z. Seismological Reports. Bringing a focus from this depth to the surface could increase the radii of his standard MM-V and MM-IV isoseismals to only 25 and 56 km respectively. Even if the highly unlikely assumption is made, that the foci of these shocks lie at the base of the crust, bringing them to the surface cannot increase the radii of the isoseismals beyond 40 and 65 km, which is still significantly below the observed values.

It is clear that no purely geometrical argument can explain the high intensities observed in the Korakonui earthquake, but re-determination of the epicentre and focal depth using only the closest recording stations affords good evidence of a very

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shallow origin. Phase arrival times at close stations are more affected by variations in focal depth, and less subject to disturbance by geological complexity along the ray path than those at more distant stations. Provided there are sufficient stations and that they are well distributed in azimuth, a calculation using only near stations is usually to be preferred.

Two such calculations were made, one using all stations within 200 km, and one using those within 150 km of the epicentre. They yield epicentre positions within three kilometres of one another, and identical within their standard errors. The computer was allowed freedom to select the most appropriate focal depth, and gave values of 4 ± 4 and 1 ± 2 km in the two cases. A real uncertainty of a few kilometres necessarily remains, but for formal purposes the solution given by the closest group of stations is satisfactory. This is:

Origin Time : 1976 Dec 05^d 04^h 57^m $16^s.7$ ± $0^s.3$

Epicentre : $38^o.17$ S ± $0^o.01$; $175^o.51$ E ± $0^o.01$

Focal Depth : 1 ± 2 km

Magnitude (K_L) : 5.0

W. D. Smith (pers.comm.) suggests that unexpectedly high intensities near an epicentre could be due to the increased excitation of short-period surface-waves when the focus is very shallow. Such waves would be very rapidly attenuated within a short distance of the epicentre, particularly if the region is geologically complex or topographically irregular, and would not contribute to magnitude determinations at the more distant stations. He will develop this hypothesis in a separate paper.

In recent times the only earthquakes west of Waikato have been small or moderate, and their felt effects imperfectly surveyed. It is therefore not possible to decide whether the high intensities observed in the Korakonui earthquake are usual in this district. Nevertheless, even a single well-observed earthquake at an abnormally shallow depth has implications that must be considered in assigning zoning factors to this part of New Zealand. Previous analyses assume that the typical focal depth of earthquakes in the Main Seismic Region is significantly greater than in this instance.

ACKNOWLEDGEMENTS

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REFERENCE

Smith, W. D., 1976: "Statistical Estimates of the Likelihood of Earthquake Shaking Throughout New Zealand." Bull. N.Z. National Society for Earthquake Engineering, Vol. 9: 213-221.

Paper received 14 October, 1977.

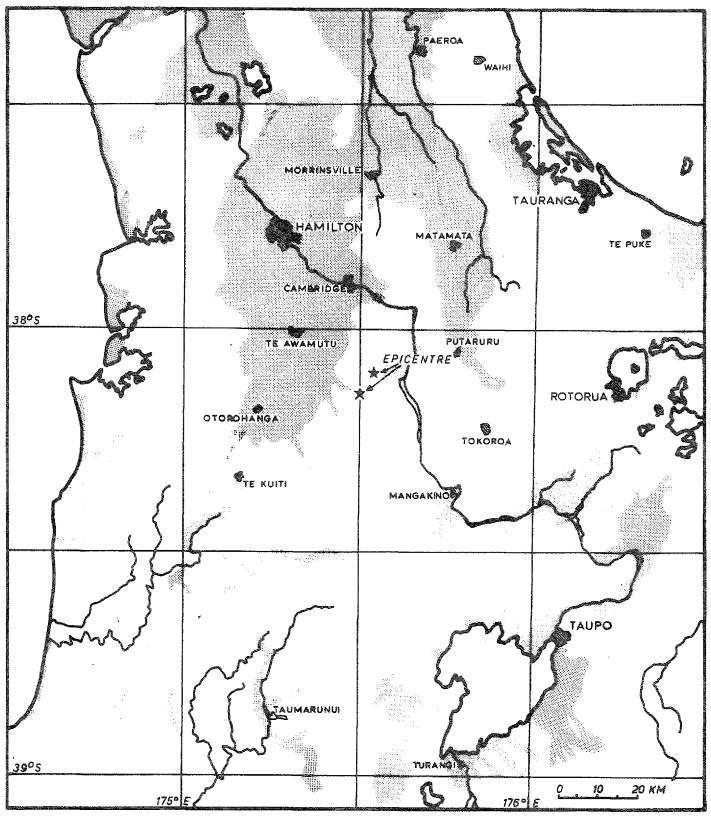

FIGURE 1: EPICENTRAL REGION OF THE KORAKONUI EARTHQUAKE. THE MORE NORTHERLY OF THE TWO EPICENTRE POSITIONS SHOWN IS THAT GIVEN IN THE N.Z. SEISMOLOGICAL REPORT. THE OTHER IS THE PREFERRED POSITION DISCUSSED AND ADOPTED IN THIS PAPER. SHADING INDICATES AREAS OF POORLY CONSOLIDATED GROUND.

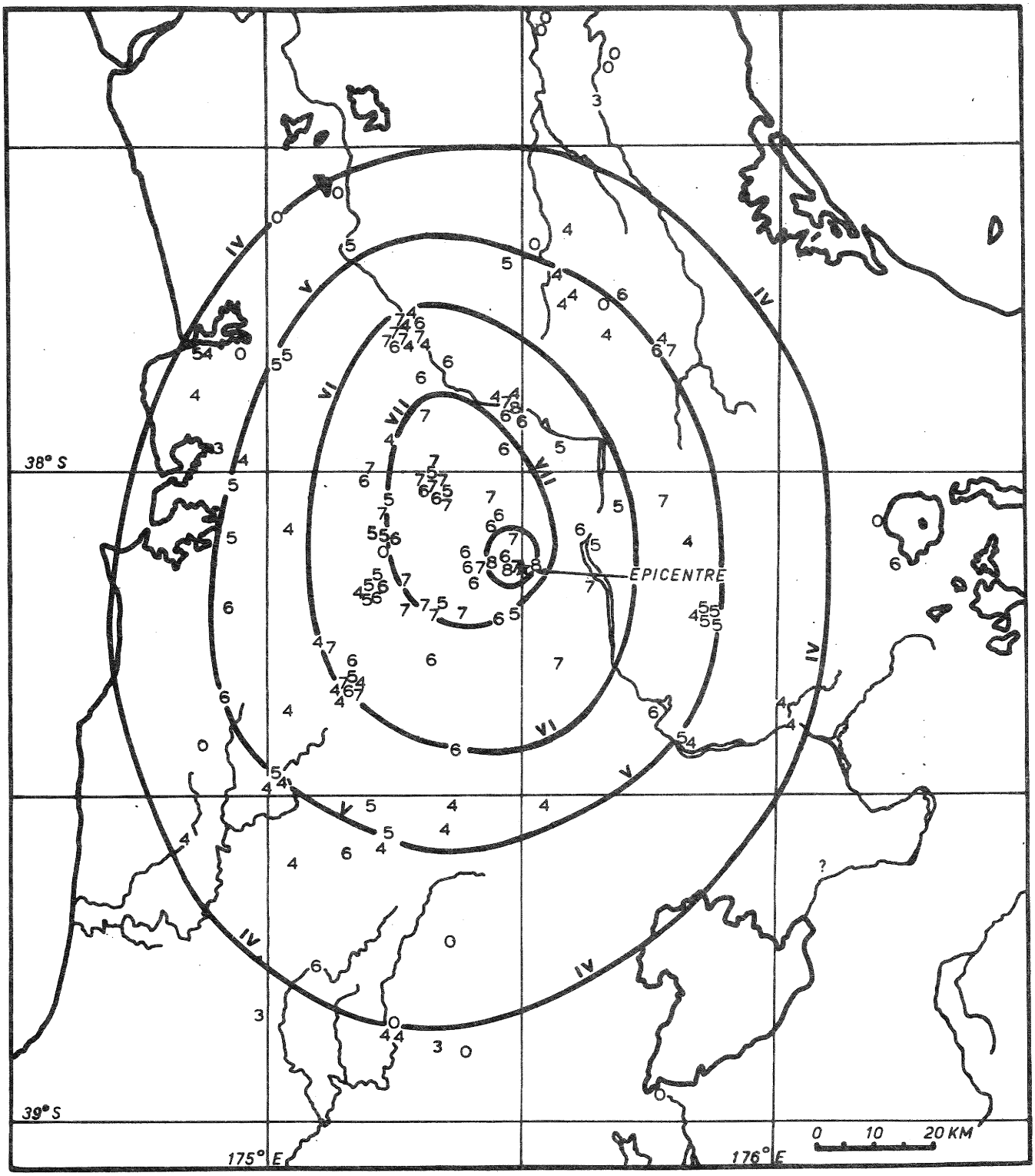

FIGURE 2: ISOSEISMALS OF THE KORAKONUI EARTHQUAKE. FIGURES SHOW SEPARATE OBSERVATIONS. A ZERO INDICATES A REPORT THAT THE SHOCK WAS NOT FELT.